Names and Numbers: "Data" in Classical Natural History, 1758–1859

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Abstract

The late eighteenth and early nineteenth centuries saw the transition from natural history to the history of nature. This paper will analyze institutional, social and technological changes in natural history associated with this epochal change. Focusing on the many posthumous re-editions of Carl Linnaeus' *Systema Naturae* that began to appear throughout Europe and beyond from the 1760 onwards, I will argue that Linnaean nomenclature and classification reorganized and enhanced flows of data—a term already used in natural history—among individual naturalists and institutions. Plant and animal species became units that could be "inserted" into collections and publications, re-shuffled and exchanged, kept track of in lists and catalogues, and counted and distributed in new ways. On two fronts—biogeography and the search for the "natural system"—this brought to the

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fore new, intriguing relationships among organisms of diverse kind. By letting nature speak through the „artificial“ means and media of early systematics, I argue, new powerful visions of an unruly nature emerged that became the object of early evolutionary theories. Natural history was an “information science” that processed growing quantities of data and held the same potential for surprising insights as today’s data-intensive sciences.

He gathered rocks, flowers, beetles of all kind for himself, and arranged them in series in manifold ways.

Novalis, *Die Lehrlinge zu Sais* (1802)[1]

1. From Natural History to the History of Nature

It has long been a trope in the historiography of the life sciences, that classical natural history—the dates in my title reflect the publication of the tenth edition of Carl Linnaeus's *Systema Naturae* and Charles Darwin's *On the Origin of Species*—underwent a massive transition, if not revolution, around 1800. Key concepts such as species, distribution, or adaptation changed from designating stable forms or states of affairs to designating fluid entities and processes extending over generations and across populations. In its ancient sense of a trustworthy account, *historia* had of course always had to do with tradition and hence with the passage of time. This is reflected in the methods early modern naturalists used, which were essentially the same as those used by humanists and antiquarians.[2] But only in the latter half of the eighteenth century was the subject matter of natural

[1] Novalis (Friedrich von Hardenberg), *Novalis' Schriften* (Berlin, 1802), vol. 2, 162: "Er sammelte sich Steine, Blumen, Käfer aller Art, und legte sie auf mannichfache Weise sich in Reihen." If not stated otherwise, translations are my own.

[2] Anthony Grafton and Nancy G. Siraisi (eds), *Natural Particulars: Nature and the Disciplines in Renaissance Europe* (Cambridge, Mass., 1999); Gianna Pomata and Nancy G. Siraisi (eds), *Historia: Empiricism and Erudition in Early Modern Europe* (Cambridge, Mass., 2005).

history—the diversity of species, their properties and uses, and their geographic, temporal and ecological distribution—infused with a sense of historicity.

This transition has been captured succinctly by historians of biology in the catchphrase "from natural history to the history of nature."[3] Explanations as to why it happened remain scant, however. Michel Foucault deliberately abstained from causal explanations in order to highlight the transition as a "mutation in the space of nature of Western culture."[4] In a surprisingly similar vein, an older anglophone tradition has emphasized paradigmatic shifts in metaphysical outlook as the precondition for the historicization of nature. By adopting a different frame of mind—by thinking in terms of geographically and temporally situated populations, rather than universal and eternal types or forms—the historical nature of species revealed itself as a corollary.[5] An interesting early attempt to close the explanatory gap that such accounts leave can be found in Wolf Lepenies' book *End of Natural History* (1976). Inspired by Foucault, Lepenies too regards natural history as going through a "crisis" at the end of the eighteenth century, but identifies it as a self-inflicted "growth crisis" (*Wachstumskrise*).[6] It was rapidly increasing "experiential pressure" (*Erfahrungsdruck*), which ultimately exhausted the capacity of spatial classification systems and forced naturalists to open up

[3] John Lyon and Phillip R. Sloan, *From Natural History to the History of Nature: Readings from Buffon and His Critics* (Notre Dame, Ind., 1981).

[4] Michel Foucault, *Les Mots et les choses. Une Archéologie des sciences humaines* (Paris, 1966), 150.

[5] Bentley Glass, Owsei Temkin, and W. L. Strauss (eds), *Forerunners of Darwin, 1745-1859* (Baltimore, 1959); Phillip R. Sloan, "Buffon, German Biology, and the Historical Interpretation of Biological Species," *British Journal for the History of Science* 12 (1979): 109–53.

[6] Wolf Lepenies, *Das Ende der Naturgeschichte. Wandel kultureller Selbstverständlichkeiten in den Wissenschaften des 18. und 19. Jahrhunderts* (Munich, 1976), 62. English translation quoted from Wolf Lepenies, *End of Natural History* (Cambridge, 1980), 74.

a temporal dimension.[7] Pointing to the series of new editions and supplements that eighteenth-century naturalists produced of their works, Lepenies explains how each attempt to reduce observations to a timeless classification system precipitated further observations that were at odds with the system adopted.[8] Natural history became historicized because naturalists experienced their own works as no more than a temporary "unifying point around which one could assemble the new facts which time brings up."[9]

Lepenies' causal association of "experiential pressure" with a period of far-reaching paradigmatic changes in the history of the life sciences is highly suggestive for any attempt to historicize the contemporary discourse of "Big Data." After all, this discourse is also rife with expectations—and fears—that "data-driven" science will be ushering in a new era in the history of knowledge simply by producing more data and developing new algorithms for processing it.[10] And there is indeed evidence that late eighteenth and early nineteenth century natural history can similarly be understood as "data-driven", since it contributed to an exceptional growth in our knowledge about particular plants and animals. While the numbers of species described—as well as the number of species believed to exist—has been growing ever since the seventeenth century, the growth curve is steepest for the period between 1760 and 1840, before it experiences a slackening from the late nineteenth century onwards.[11] But there are problems too with Lepenies' explanation. As suggestive

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[7] Lepenies, *Ende der Naturgeschichte* (cit. n. 6), 18; Lepenies, *End of Natural History*, 15.

[8] Ibid., 76.

[9] Ibid., 93.

[10] See Aronova, von Oertzen and Sepkoski, this volume, and Kaplan, this volume.

[11] Given how often growth in species number is invoked to explain historical developments in natural history, actual data are surprisingly scarce. I am relying on Sara T. Scharf, "Identification Keys and the Natural Method:

as the association is, mere quantitative growth of knowledge does simply not furnish any compelling reason to adopt a particular worldview, whether historicist or not.[12] More interesting problems arise when we confront Lepenies' account with the following statement by the young Alexander von Humboldt (1769–1859) from one of his first publications, a small book he published on "some basaltic rocks at the Rhine" in 1797:

> Every plant is certainly not allocated to every rock as its domicile. Nature follows unknown laws here, which can only be investigated by means of botanists administering more data to induction (*Data zur Induction darreichen*).[13]

Humboldt's statement first of all shows that data talk is not the hallmark of modernity narrowly understood. The Latin past participle of *dare*, simply meaning "given", had long been in use in natural history to refer to any kind of information—a detailed description, a drawing, a preserved specimen, or just the name—that had been handed down about a particular subject.[14] Secondly, and

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The Development of Text-Based Information Management Tools in Botany in the Long Eighteenth Century" (PhD thesis, Univ. of Toronto, 2006), 31–42, who analyzes data for plants, mushroom, insects, fish, birds and mammals.

[12] Phillip R. Sloan, Review of *Das Ende der Naturgeschichte*, by Wolf Lepenies, *Isis* 72 (1981): 123–24.

[13] Alexander von Humboldt, *Mineralogische Beobachtungen über einige Basalte am Rhein* (Braunschweig, 1790), 86.

[14] See, for example, Carl Linnaeus, *Hortus Cliffortianus* (Amsterdam, 1737), "Bibliotheca botanica" (unpag.), who refers to Johannes Bauhin's *Historia Plantarum Universalis* (Yverdon, 1650–1651) as containing "all that was given by [his] forebears" (*omnis data a praecessoribus*). The word "data" occasionally occurred in English natural history texts as well; see for example, John Woodward, *The Natural History of the Earth: Illustrated, Enlarged, and Defended* (London, 1726), 149. More specifically, Humboldt's language of "data" and "induction" reveals the influence of Immanuel Kant, who had argued that empirical sciences like natural

more importantly, it is notable that Humboldt employed the language of "data" not to complain about its overabundance, as one would expect on Lepenies' account, but on the contrary, to complain about its scarcity. Such a call for "more" data in a world that otherwise bemoaned "too much" data is not at all exceptional and only seemingly paradoxical. Naturalists like Humboldt were both creators and users of data, and thus involved in an endless cycle of consuming data for the sake of producing them. The crucial problem of any data-driven science is therefore not just to come to terms with ever-growing bodies of data but also to make those data commensurate to as many contexts of inquiry as possible.[15] The target of Humboldt's statement was a highly specialized subject—the distribution of plant species as a function of geological substrate, and hence their use as indicators in the search for mineral deposits—but it was hardly untrodden terrain; quite on the contrary, knowledge of correlations between particular plant kinds and particular kinds of rock had a very long and rich tradition in mining.[16] Hence, if there was a scarcity of data, it was a scarcity of data produced in a manner that could readily be consumed and processed. Finally, Humboldt's statement also highlights that producing general knowledge from "data" through "induction" is not a matter of individual psychology and experience, but relies on the results of a collective endeavor of trained specialists, a group that Humboldt himself was aiming to become part of at this point in his life.[17]

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history or chemistry are uncertain and incomplete since they rely on "data of intuition" (*datis der Anschauung*); see Ursula Klein, "The Prussian Mining Official Alexander von Humboldt," *Annals of Science*, 69 (2012): 27–68, on 54–55. See Aronova, Oertzen and Sepkoski, this volume, and Krajewski, this volume, for further discussion of the history of the word "data".

[15] Sabina Leonelli, "Integrating Data to Acquire New Knowledge: Three Modes of Integration in Plant Science," *Studies in History and Philosophy of Biological and Biomedical Sciences* 44 (2013): 503–514.

[16] Ursula Klein, *Humboldts Preußen: Wissenschaft und Technik im Aufbruch* (Darmstadt, 2015), 95.

[17] Klein, "Alexander von Humboldt" (cit. n. 14), 29.

Naturalists were not passively exposed to a data deluge—or a data dearth, for that matter—but collectively shaped the channels through which data would flow. It was thus the naturalists themselves that defined the conditions under which data were perceived as abundant or scarce.[18]

A careful reading of Humboldt's early call for "more data" thus reminds us that solutions to epistemological problems of "data-driven science"—whether in its early modern or contemporary incarnations—are not simply conceptual or theoretical, but also technological and infrastructural. Taking this conclusion on board, the next section is going to explore social and institutional changes that natural history underwent in its classical period from Linnaeus to Darwin. In particular, I want to highlight the integrative role that Linnaean nomenclature and taxonomy played in this period which otherwise saw a diversification of agents, institutions and cultures of natural history. The third and fourth section will then focus on how Linnaean names and taxa were used as tools to organize exchange and retrieval of data. I will show that the adoption of these tools not only enhanced data circulation, but also had peculiar epistemic effects, by turning species and other taxa into objects that were numbered and counted, not only for purposes of administering collections or structuring publications, but also to reveal intriguing patterns in the geographic and taxonomic distribution of life forms. Only then, in a concluding section, will I return to the question whether one can thus indeed claim that a causal connection exists between the data-driven nature of classical natural history and the discursive ruptures that so many historians have associated with the era "around 1800."

[18] See Friedrich, this volume, for the parallel case of early modern genealogy.

2. The Changing Landscape of Classical Natural History

Late eighteenth- and early nineteenth-century natural history experienced social and institutional changes that involved both diversifying and centralizing tendencies. On the one hand, its basis of practitioners grew massively and came to include non-university trained men and women as well, both within and outside of Europe, and across social classes. Amateur naturalists did not only engage in collecting specimens, maintained epistolary exchanges, and eventually published their observations; they also began to organize themselves from the bottom up in local and regional associations that often maintained their own periodical publications.[19] Rising levels of literacy and the spread of cheap print widened the potential audience for, and made it easier to contribute to, natural history.[20] At the same time, there was an increasing demand for experts trained in natural history to fill a growing number of professional positions, both in state bureaucracies like mining boards, within the management of agricultural, industrial and commercial enterprises, and, as we will see presently, in large collections and museums.[21] Needless to say that this held in particular for

[19] Ann B. Shteir, *Cultivating Women, Cultivating Science: Flora's Daughters and Botany in England, 1760 to 1860* (Baltimore, 1999); Roger L. Williams, *Botanophilia in Eighteenth-Century France: The Spirit of the Enlightenment* (Dordrecht 2001); Bettina Dietz, "Making Natural History: Doing the Enlightenment," *Central European History* 43 (2010): 25–46.

[20] George S. Rousseau, "Science books and their readers in the eighteenth century," in *Books and their Readers in Eighteenth-Century England*, ed. Isabel Rivers (New York: 1982), 197–255; Denise Phillips, *Acolytes of Nature: Defining Natural Science in Germany, 1770–1850* (Chicago, 2012).

[21] Bruno Belhoste, *La Formation d'une technocratie. L'École polytechnique et ses élèves de la Révolution au Second Empire* (Paris, 2003); Ursula Klein, "Artisanal-scientific experts in eighteenth-century France and Germany," *Annals of Science* 69 (2012): 303–6.

organizations and enterprises engaged in long-distance trade and colonial expansion.[22] Participation in the global "information economy" of natural history, and the "logistical power" this endowed upon its practitioners, thus provided an essential stepping stone for the middling classes to enter various occupations and careers of an administrative, brokering or entrepreneurial nature.[23]

While these developments led to a growing diversification of both objects and sources of natural history, a counterbalance existed in the rise of a new set of central nodes around which natural history exchange revolved. With a few exceptions, early modern natural history collections were associated with court or university culture, and to a lesser extent with organizations involved in long-distance trade, like the *Casa de Contratación* in Spain, or the Dutch East India Company.[24] Until the

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[22] Roy MacLeod, ed., *Nature and Empire: Science and the Colonial Enterprise*, vol. 15 of *Osiris* (Chicago, 2000); Mauricio Nieto, *Remedios para el imperio. Historia natural y la apropiación del Nuevo Mundo* (Bogotá, 2000); Londa L. Schiebinger and Claudia Swan (eds), *Colonial Botany: Science, Commerce, and Politics in the Early Modern World* (Philadelphia, 2005).

[23] Harold John Cook, *Matters of Exchange: Commerce, Medicine, and Science in the Dutch Golden Age* (New Haven, CT, 2007); Simon Schaffer, Lissa Roberts, Kapil Raj, and James Delbourgo (eds), *The Brokered World: Go-Betweens and Global Intelligence, 1770-1820* (Sagamore Beach, Mass., 2009). For intriguing examples, see David Arnold, "Plant Capitalism and Company Science: The Indian Career of Nathaniel Wallich," *Modern Asian Studies* 42 (2008): 899–928, and Minakshi Menon, "Medicine, Money, and the Making of the East India Company State: William Roxburgh in Madras, c. 1790," in *Histories of Medicine and Healing in the Indian Ocean World*, Vol. 1, *The Medieval and Early Modern Period*, ed. Anna Winterbottom and Facil Tesfaye, (London, 2015), 151–178. Menon borrows the concept of "logistical power" from Chandra Mukerji, "The Territorial State as a Figured World of Power: Strategics, Logistics, and Impersonal Rule," *Sociological Theory* 28 (2010): 402–24.

[24] Oliver Impey and Arthur MacGregor, eds., *The Origins of Museums. The Cabinet of Curiosities in Sixteenth- and Seventeenth-Century Europe* (Oxford1985); Paula Findlen, *Possessing Nature: Museums, Collecting, and*

mid-eighteenth century, however, exchange of specimens, letters and publications turned around the individuals who presided over these collections, such as Sir Hans Sloane (1660-1753), Georges Buffon (1707–1788) or Carl Linnaeus (1707–1778). By the early nineteenth century central institutions that were there to stay had taken over this role—the Jardins des Plantes and Muséum d'Histoire Naturelle in Paris, Kew Gardens and the British Museum in London, or Berlin University with its gardens and collections in Prussia, to name just a few.[25] Two important structural features distinguished the "new" museums from their early modern counterparts.[26] First, they represented collections of collections rather than collections *tout court*. Often starting out with the acquisition of a large, single collection—Sloan's collection in the case of the British museum, or Linnaeus's collection in the case of the Linnean Society (London)—these museums expanded by acquiring entire collections or commissioning naturalists to hunt for specimens on a global scale.[27] The most striking

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Scientific Culture in Early Modern Italy (Berkeley, CA, 1994); Pamela Smith and Paula Findlen (eds), *Merchants and Marvels: Commerce, Science, and Art in Early Modern Europe* (London, 2001); Antonio Barrera-Osorio, *Experiencing Nature: The Spanish American Empire and the Early Scientific Revolution* (Austin, TX, 2006).

[25] Emma C. Spary, *Utopia's Garden: French Natural History from Old Regime to Revolution* (Chicago, 2000); Richard Drayton, *Nature's Government: Science, Imperial Britain, and the "Improvement" of the World* (New Haven, CT, 2000); Staffan Müller-Wille and Katrin Böhme, "Biologie: Wissenschaft vom Werden, Wissenschaft im Werden," in *Genese der Disziplinen: Die Konstitution der Universität*, vol. 4 of *Geschichte der Universität Unter den Linden, 1810-2010*, ed. Elmar Tenorth, Volker Hess and Dieter Hoffmann (Berlin, 2010), 425–46.

[26] Paul Lawrence Farber, *Finding Order in Nature: The Naturalist Tradition from Linnaeus to E.O. Wilson* (Baltimore, 2000), 22–30; Dorinda Outram, "New Spaces in Natural History," in *Cultures of Natural History*, ed. Nicholas Jardine, Jim A. Secord, and Emma C. Spary (Cambridge, 1996), 249–65.

[27] On Sloane, whose collection already was a collection of collections, see James Delbourgo, "Collecting Hans Sloane," in *From Books to Bezoars: Sir Hans Sloane and his Collections* (London, 2012), 9–23; on Linnaeus, see Paul White, "The Purchase of Knowledge: James Edward Smith and the Linnaean Collections" *Endeavour* 23

case of this is provided by the Muséum d'histoire naturelle in Paris after the French Revolution, which received a boost to its possessions from the confiscation of aristocratic collections, whose provenances and contents were carefully noted in a card catalogue.[28]

Secondly, and concomitantly, museums were increasingly organized into specialized departments offering a hierarchy of positions for curators or "keepers" and various amanuenses who administered and enriched the collections. A new generation of professional naturalists emerged, often socialized through participation in long-distance natural history exploration, during which they collected for their patrons or institutions, and then moving on to curatorial positions in metropolitan collections and libraries. Daniel Solander (1733-1782), who accompanied Joseph Banks on Cook's first circumnavigation as one of the many travelling students or "apostles" of Linnaeus, is often cited as the first exemplar. Robert Brown (1773–1858)—who went with Flinders's expedition to Australia (1801–1805), followed Solander as Bank's librarian, and finally, after Joseph Banks's death, became "Keeper of the Banksian Botanical Collection" at the British Museum in 1827—is another well-known example.[29] Similar relationships unfolded in Paris, both at the Jardin des Plantes and Muséum

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(1999), 126–29. On travelling collectors, see Marie-Noëlle Bourguet, "La collecte du monde: voyage et histoire naturelle (fin XVIIème –début XIXème siècle)," in *Le muséum au premier siècle de son histoire*, ed. Claude Blanckaert, Claudine Cohen, Pietro Corsi, and Jean-Louis Fischer (Paris, 1997), 163–96; Daniela Bleichmar and Peter C. Mancall (eds), *Collecting across Cultures: Material Exchanges in the Early Modern Atlantic World* (Philadelphia, 2011); Fa-ti Fan, *British Naturalists in Qing China: Science, Empire, and Cultural Encounter* (Cambridge, Mass., 2004).

[28] Pierre-Yves Lacour, *La République naturaliste. Collections d'histoire naturelle et Révolution française. 1789-1804* (Paris, 2014).

[29] Edward Duyker, *Nature's Argonaut: Daniel Solander 1733-1782: Naturalist and Voyager with Cook and Banks* (Melbourne, 1998); David J. Mabberley, *Jupiter Botanicus: Robert Brown of the British Museum* (Braunschweig,

National d'Histoire Naturelle and in large private collections like that of the banker and industrialist Benjamin Delessert (1773–1847).[30]

The knowledge networks that underwrote natural history were thus not just expanding and diversifying. At the same time, central institutions emerged that provided positions for "information brokers" who saw their task primarily in serving an imagined community of naturalists by mediating and organizing flows of data.[31] This double process of diversification and centralization turned natural history into an increasingly disparate field. Classical natural history never constituted a homogeneous and uniform knowledge regime, governed by a common paradigm or episteme. Peter F. Stevens coins the interesting phrase of "continuity in practice" to highlight how naturalists discarded the idea of one timeless and universal system in which every conceivable species would find its place and began to join species one by one into open-ended series instead.[32] James L. Larson reaches a similar conclusion; by the late eighteenth century, natural history had fallen apart into highly specialized areas, such as comparative morphology, biogeography, or the study of hybrids,

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1985). On Linnaeus' "apostles", see Sverker Sörlin, "Ordering the world for Europe: Science as intelligence and information as seen from the Northern periphery," in Macleod, *Nature and Empire* (cit. n. 21), 51–69.

[30] See Jean-Marc Drouin, "Collecte, observation et classification chez René Desfontaines (1750-1833)," in *Le muséum* (cit. n. 26), 263–76; Thierry Hoquet, "Botanical Authority: Benjamin Delessert's Collections between Travelers and Candolle's Natural Method (1803–1847)," *Isis* 105 (2014): 508–39.

[31] The dynamic continues; see Benson, this volume, on citizen science in twentieth-century ornithology; see also Geoffrey C. Bowker, "Biodiversity Datadiversity," *Social Studies of Science* 30 (2000): 643–83; Sabina Leonelli, "Classificatory Theory in Data-Intensive Science: The Case of Open Biomedical Ontologies," *International Studies in the Philosophy of Science* 26 (2012): 47–65.

[32] Peter F. Stevens, *The Development of Systematics: Antoine-Laurent de Jussieu, Nature and the Natural System* (New York, 1994), 153.

and each of these areas had become the subject of methodologically autonomous pursuits that could do without integration into an overarching natural-philosophical or theological system.[33] The urge to synthesize particulars, to be sure, persisted, but increasingly found expression in the development of highly specialized "tools of conjecture" deployed in narrowly defined subject areas.[34]

There is one element of unity to classical natural history, however, that has been recognized widely ever since the late eighteenth century. Within two decades of their introduction in *Philosophia Botanica* (1751), the two innovations that formed the cornerstones of Linnaeus's self-styled "reform" of natural history—the naming of plant and animal species by "trivial" names composed of genus name and specific epithet (as in *Homo sapiens*); and their ordering by variety, species, genus, order (or family) and class, the so-called Linnaean hierarchy of taxonomic ranks—had been universally adopted by naturalists, even by prominent opponents of Linnaeus like Buffon or Jean-Baptiste de Lamarck (1744–1829).[35] It is telling, however, that these innovations have habitually

[33] James L. Larson, *Interpreting Nature: The Science of Living Form from Linnaeus to Kant* (Baltimore, 1994).

[34] On "tools of conjecture", see Lorraine Daston, "The Empire of Observation, 1600-1800," in *Histories of Scientific Observation*, ed. Lorraine Daston and Elizabeth Lunbeck (Chicago 2011), 81–113, on 104–6. For case studies, see Mary Terrall, "Following Insects around: Tools and Techniques of Eighteenth-Century Natural History," *The British Journal for the History of Science* 43 (2010): 573–88; Bettina Dietz, "Mobile Objects: The Space of Shells in Eighteenth-Century France," *British Journal for the History of Science* 39 (2006): 363–82.

[35] For eighteenth-century accounts that already highlighted the near-universal adoption of Linnaeus' nomenclature, see Jean-Antoine-Nicolas de Caritat Condorcet, "Éloge de Linné", *Histoire de l'Academie des Sciences* 1778 (1781), 66–84, on 72–73; Félix Vicq-d´Azyr, "Linné (Charles)" (1780), in *Éloges historiques par Vicqd ´Azyr*, 3 vols., ed. J. L. Moreau (Paris, 1805), 1:169–208, on 198; and James Edward Smith, "Introductory discourse on the rise and progress of natural history", *Transactions of the Linnean Society of London* 1 (1791): 1–55, on 53. On the reception of Linnaeus in France, see Pascal Duris, *Linné et la France (1780-1850)* (Genève,

been characterized as being of pragmatic value only. According to the botanist Frans Stafleu, author of the most comprehensive history of the early reception of Linnaean nomenclature and taxonomy, Linnaeus conceived of natural history not as a "science of obtaining insight into the history, structure, and functioning of the [living] world, but primarily as a device to register and to remember, to store and to retrieve."[36]

It is indeed tempting to assume with Stafleu that stable, arbitrary names and a nested hierarchy of taxonomic units are of obvious practical value in communication, but neutral with respect to the knowledge they transport. As historical analyses of the origin and early reception of Linnaean nomenclature and taxonomy have revealed, it was precisely this feature that made them attractive to naturalists in their pursuit for ever enhanced levels of data accumulation, circulation and collaboration in natural history.[37] Yet it seems highly improbable, after all we know from work in the history and philosophy of science in the decades since its "practical turn," that this should not have had epistemic consequences as well.[38] In the following section, I will adopt a perspective that looks

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1995). Linnaean nomenclature was also adopted outside of Europe; see Antonio Lafuente and Nuria Valverde, "Linnaean Botany and Spanish Imperial Biopolitics," in Schiebinger and Swan, *Colonial Botany* (cit. n. 21), 134–47.

[36] Frans A. Stafleu, *Linnaeus and the Linnaeans: The Spreading of Their Ideas in Systematic Botany, 1735-1789* (Utrecht, 1971), 33.

[37] William T. Stearn, "The Background of Linnaeus´s contributions to the nomenclature and methods of systematic biology," *Systematic Zoology* 8 (1959): 4–22; Lisbet Koerner, *Linnaeus: Nature and Nation* (Cambridge, Mass., 1999), ch. 2; Daniel R. Headrick, *When Information Came of Age: Technologies of Knowledge in the Age of Reason and Revolution, 1700-1850* (Oxford, 2000), ch. 2.

[38] For the same reason, it is unlikely that contemporary digital technologies will result in nothing but a "scaling-up of pen-and-paper methods"; see Stevens, this volume.

at binary names and the Linnaean hierarchy as tools to process information on paper. This will prepare the ground for my argument in the subsequent section that the way in which "information brokers" in classical natural history deployed these tools—both in order to collect and process data on plants and animals and to navigate the increasingly complex social landscape of natural history—did have epistemic consequences by turning species and other taxa into objects that could be counted and whose number mattered.

3. Paper Tools and Paper Empires

One of the most astonishing aspects of Linnaeus' taxonomic publications is the success they enjoyed in terms of print runs, especially if one considers that these were not books made for leisurely reading or intellectual entertainment, but catalogues filled with names of genera and species, references to earlier literature, short morphological descriptions, and cryptic remarks about geographic and ecologic distribution (see Fig. 1). Linnaeus himself counted twelve editions of his *Systema naturae* between 1735 and 1768—growing from an eleven-page folio volume to four octavo volumes of all in all 2441 pages—six editions of *Genera plantarum* from 1737 to 1764, and two editions of *Species plantarum* (1753 and 1762).[39] But the success went far beyond Linnaeus as a person. From the late 1760s onwards, but especially after Linnaeus's death in 1778, other naturalists began to publish editions, translations and adaptations of these works, often adopting their main title and citing Linnaeus as author on the title page, or acknowledging their debt to his work in subtitles or prefaces. The most complete bibliography of Linnaeana lists about fifty posthumous items of this kind for *Systema Naturae* alone. A number of these continued Linnaeus's own counting of editions, so there exists a sixteenth edition of the botanical part of *Systema naturae*, which was

[39] See Carl Linnaeus, *Systema Naturae*, 12th ed., 4 vols. (Stockholm: Salvius, 1766–1768), 1(1766):Ratio editionis [unpag.], for a list of "authorized" editions of *Systema Naturae*.

issued in Göttingen in five volumes from 1825 to 1828, a two-volume ninth edition of *Genera plantarum* (Göttingen, 1830–1831), and an aborted sixth edition of *Species plantarum* (Berlin, 1831–1833), whose two hefty volumes only managed to cover plants of two out of twenty-four classes of the Linnaean system.[40]

[FIGURE 1]

The lasting success of Linnaeus' taxonomic work is often explained by claiming that Linnaean nomenclature and taxonomy provided naturalists with the means to refer to plant and animal kinds unambiguously, thus clearing the previous chaos of synonymy and conflicting classifications.[41] But what allows for unequivocal reference in modern taxonomy are not binary names as such but the type method, i.e. the method of associating taxonomic names with fixed taxon elements, such as type specimens or species; and this method only began to emerge in the second half of the nineteenth century.[42]

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[40] B. H. Soulsby, *A Catalogue of the Works of Linnaeus (and Publications More Immediately Relating Thereto) Preserved in the Libraries of the British Museum (Bloomsbury) and the British Museum (Natural History) (South Kensington)*, 2nd ed. (London, 1933), no. 64–169, 284–327, 480–529, 573–619. Linnaeus's works were also printed in North and South America, and one of the editions listed by Soulsby for the twelfth edition of *Systema naturae* was printed in Jakarta in 1783 (no. 104–105). A search of the online Linnaeus Link Union Catalogue (URL = http://www.linnaeuslink.org/), which builds on Soulsby's catalogue, produces 37 results for titles containing the words "systema" and "naturae" published between 1768 and 1859.

[41] For a succinct statement of this view, see the „epilogue" in Stafleu, *Linnaeus and the Linnaeans* (cit. n. 35), 337–339.

[42] Gordon R. McOuat, "Species, Rules and Meaning: The Politics of Language and the Ends of Definitions in 19th Century Natural History," *Studies in History and Philosophy of Science* 27 (1996): 473–519; Christophe Bonneuil, "The Manufacture of Species: Kew Gardens, the Empire and the Standardisation of Taxonomic

Linnaeus himself, when introducing binary names and the five-tiered hierarchy of taxonomic ranks, advertised an advantage that was quite a different from disambiguation. Traditional, or "legitimate" names as Linnaeus called them (*nomina legitima*), were composed of the genus name and a diagnostic phrase spelling out traits by which the named species differed from all other known species of the same genus. The function of such names was thus not just to designate a species, but also to assign to it a definite position in contradistinction to already known species; without this context, legitimate names did not make much sense. The "trivial" or binary name, in contrast, just added a "single word [...] freely adopted from anywhere" to the genus name. Hence, as Linnaeus emphasized, it was not only shorter and more easily reproduced, but above all more stable, since it did not have to be changed in order to keep the designated species distinct from newly discovered species.[43] In highlighting the advantage of a "systematic" arrangement by class, order, genus, species

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Practices in Late 19th Century Botany," in *Instruments, Travel and Science: Itineraries of Precision from the 17th to the 20th Century*, ed. Marie-Noëlle Bourguet, Christian Licoppe, and Heinz Otto Sibum (London, 2002), 189–215; Lorraine Daston, "Type Specimens and Scientific Memory," *Critical Inquiry* 31 (2004): 153–82; Joeri Witteveen, "Suppressing Synonymy with a Homonym: The Emergence of the Nomenclatural Type Concept in Nineteenth-Century Natural History," *Journal of the History of Biology* 49 (2015), 135–89.

[43] Carl Linnaeus, *Philosophia Botanica* (Stockholm, 1751), 98. Linnaeus' terminology sounds slightly odd to modern ears. "Legitimate" (*legitima*) indicated that the name was formed in accordance with the long established rules of dignosis, whereas "trivial" (*trivialis*) meant public or commonplace. Linnaeus indeed choose trivial names "arbitrarily", i.e. from a wide variety of sources, including vernacular languages; see Alexandra Cook, "Linnaeus and Chinese Plants: A Test of the Linguistic Imperialism Thesis," *Notes and Records of the Royal Society of London* 64 (2010): 121–38. The classicist John Louis Heller has argued that Linnaeus' trivial names grew out of the practice to cite the name of the author when referring to a particular species within a genus; see Heller, "On Linnaean Trivial Names", in *Studies in Linnaean Method and Nomenclature* (Marburg, 1983), 277–305.

and variety (*systema*), Linnaeus drew on a similar contrast with the traditional "key" (*clavis*) that was constructed by adopting a series of "arbitrary dichotomies" (*dichotomias arbitraria*). Whereas these could guide naturalists "along their way" in identifying known kinds of organisms, they could not stake out the "borders" (*limites*) of these kinds, as Linnaeus put it. Moreover, whereas each step in a dichotomous key would only double the number of distinguished taxonomic units, a "system" could proceed in a much more efficient manner through a series of multiple taxa nested within higher taxa. A class, for example, could contain ten orders, each of these orders another ten genera, and so on, just like countries or armies form nested hierarchies of multiple administrative and military units. The identity of the ranks constituting the Linnaean hierarchy is thus likewise not determined by any particular difference they happen to exhibit with respect to other taxa, but by what they contain and come to contain.[44] Linnaean names were mere indexes or labels, whereas the Linnaean hierarchy simply provided a nested set of containers, or "boxes within boxes," defined extensionally only by the set of objects they contained (or denoted).[45] In short: Linnaean nomenclature and taxonomy emphasized equivalence, not difference, a point to which I will come back.

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[44] Linnaeus, *Philosophia Botanica* (cit. n. 42), 202. For an English translation of the relevant aphorisms on trivial names and the five-tired system of ranks, see *Linnaeus' Philosophia Botanica*, transl. Stephen Freer (Oxford, 2005), 99–100 and 207–8. I am intentionally ignoring the complication that the "system" Linnaeus was most famous for, the "sexual system" of plant classification, was actually a „key" and hence considered "artificial" by Linnaeus already; see Staffan Müller-Wille, "Collection and Collation: Theory and Practice of Linnaean Botany," *Studies in History and Philosophy of the Biological and Biomedical Sciences* 38 (2007): 541–62. This point will come up again, however, at the end of section 4.

[45] I am borrowing the language of labels and containers from Sabina Leonelli, "Packaging small facts for re-use: databases in model organism biology," in *How Well Do Facts Travel? The Dissemination of Reliable Knowledge*, ed. Peter Howlett and Mary S. Morgan (Cambridge, 2010), 325–48, and James Delbourgo, "What's in the Box?," *Cabinet Science* 41, Spring Issue (2011): 47–50. For an eighteenth-century case study that employs

To gain a better understanding of how binary nomenclature and the hierarchy of ranks facilitated communication among naturalists, it is useful to look at the role they played in the creation of *paper tools*—or devices made from paper and ink, whether in manuscript or print—that were employed in practices of extracting and processing written information like note taking, listing, cataloguing or tabulating.[46] Up to the early eighteenth century, the predominant methods scholars used for annotation had been marginalia and topically organized commonplace books, that is, media that tended to fix information in relation to a relevant (con-)text.[47] The late seventeenth and eighteenth centuries witnessed a transition to more flexible paper tools, like loose files and card catalogues, and to more complex techniques of extracting, rearranging and displaying information, like forms, tables, diagrams and maps, often employed for highly idiosyncratic purposes.[48] Linnaeus participated in this transition by experimenting throughout his career with a diversity of annotation and filing systems,

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similar analytic categories, see Anke te Heesen, "Boxes in Nature," *Studies in History and Philosophy of Science* 33 (2000): 381–403.

[46] On the concept of paper tools, see von Oertzen, this volume; Anke te Heesen, "The Notebook: A Paper-Technology," in *Making Things Public: Atmospheres of Democracy*, ed. Bruno Latour and Peter Weibel (Cambridge, Mass., 2005), 582–89; Volker Hess and Andrew Mendelsohn, "Paper technology und Wissensgeschichte," *NTM – Zeitschrift für Geschichte der Wissenschaften, Technik und Medizin* 21 (2013): 1-10.

[47] Ann M. Blair, *Too Much to Know: Managing Scholarly Information before the Modern Age* (New Haven, 2010); Richard Yeo, *Notebooks, English Virtuosi, and Early Modern Science* (Chicago, 2014).

[48] Anke te Heesen, "Accounting for the Natural World: Double-Entry Bookkeeping in the Field," In Schiebinger and Swan, *Colonial Botany* (cit. n. 21), 237–51; Isabelle Charmantier and Staffan Müller-Wille, "Worlds on Paper: An Introduction," *Early Science and Medicine* 19 (2014): 379–397; Volker Hess and J. Andrew Mendelsohn, "Case and Series: Medical Knowledge and Paper Technology, 1600–1900," *History of Science* 48 (2010): 287–314.

various forms of lists and tables, and, towards the end of his life, with paper slips that resemble index cards. In all of these media, Linnaean taxa carved out an allocated paper space—whether on the printed pages of a book, in a handwritten list or table, in the form of a file produced from folded paper sheets, or by cutting paper into small slips of a standard size—that was labeled with the name of a genus or species and then used to collect pieces of information contained under that name. Since the name itself was a mere label, the resulting packages of data could be freely extracted from their context, and their contents inserted, or even redistributed, elsewhere, without loosing their identity as long as the label stuck.[49] As Linnaeus put it in a remarkable metaphor in 1737 already, defining the role of generic names:

> The generic name has the same value on the market of botany, as the coin has in the commonwealth, which is accepted at a certain price—without needing a metallurgical assay—and is received by others on a daily basis, as long as it has become known in the commonwealth.[50]

What this metaphor clearly expresses is that Linnaean names and ranks did not derive their value from any information they may have contained themselves, but by providing others with the material means to access, accumulate and exchange data.[51] *Species Plantarum, Genera Plantarum*

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[49] Staffan Müller-Wille and Isabelle Charmantier, "Natural History and Information Overload: The Case of Linnaeus," *Studies in History and Philosophy of Biological and Biomedical Sciences* 43 (2012): 4–15; Staffan Müller-Wille and Isabelle Charmantier, "Lists as Research Technologies," *Isis* 103 (2012): 743–52; Isabelle Charmantier and Staffan Müller-Wille, "Carl Linnaeus's Botanical Paper Slips (1767–1773)," *Intellectual History Review* 24 (2014): 1–24.

[50] Carl Linnaeus, *Critica Botanica* (Leiden, 1737), 204.

[51] The metaphor of data as currency is also found in twentieth-century sciences; see Aronova, this volume.

and *Systema Naturae* were designed to serve as templates for communal annotation, whether this took the form of creating a numbered list of the names of specimens or seeds sent to a correspondent, or whether an interleaved copy of one of these works was used to absorb new data gathered from reading the latest literature, from a letter received by a correspondent, or during field excursions. Linnaeus himself employed his publications for this purpose (see fig. 1), thus being able to churn out one edition after the other on the basis of data received from correspondents, and there is growing evidence that other naturalists quickly adopted the same kind of strategies.[52] Drawing on an analogy from our digital age, one might claim that the formal structure of Linnaean nomenclature and taxonomy provided naturalists with the rows or "objects" of a crowd-sourced database; the columns, in turn, were constituted by "variables" such as morphological features, economic uses and habitat or geographic origin of the species in question.[53]

This explains one curious aspect of the many "editions" and "translations" of Linnaeus's taxonomic work, namely that, strictly speaking, they were not editions or translations at all. As Bettina Dietz has emphasized in a recent article, they rather continued his taxonomic project by incorporating new

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[52] On the important role of specimen lists in correspondence, see Spary, *Utopia's Garden* (cit. n. 24), 61–78; Bettina Dietz, "Contribution and Co-production: The Collaborative Culture of Linnaean Botany", *Annals of Science* 69 (2012): 551–69. On Linnaeus annotating interleafed copies of his own taxonomic works, see Staffan Müller-Wille and Sara Scharf, "Indexing Nature: Carl Linnaeus and His Fact Gathering Strategies," *Svenska Linnesällskapets Årsskrift* 2011 (2012): 31–60. For an example of a naturalist adopting this practice, see Katrin Böhme and Staffan Müller-Wille, "'In der Jungfernheide hinterm Pulvermagazin frequens'. Das Handexemplar des *Florae Berolinensis Prodromus* (1787) von Carl Ludwig Willdenow," *NTM Zeitschrift für Geschichte der Wissenschaften, Technik und Medizin* 21 (2013): 93–106.

[53] See Sepkoski, this volume, for an analysis of the limitations and potentials of applying this metaphor to pre-digital media.

data.[54] Many of the editors of these works pointed this out explicitly. The Dutch physician and naturalist Martinus Houttuyn (1720–1798), for example, stated in his *Natuurlyke Historie*—issued from his cousin's printshop between 1761 and 1785—that he had adopted Linnaeus's "system" (*Samenstel*) and "Latin bynames" (*Latynsche Bynaamen*), but only to add that he had also inserted information from publications by other naturalists such as Buffon in Paris, or Jacob Theodor Klein (1685-1759) in Danzig, whose works rivaled with that of Linnaeus in scope and authority.[55] Philipp Ludwig Statius Müller (1725–1776) made similar remarks in the preface to his German edition of *Systema Naturae*. In the very first sentence, Müller stated that the reader should "not expect a translation," either of the twelfth edition of Linnaeus's *Systema Naturae* or of Houttuyn's *Natturlyke Historie*. Instead, Müller's work as well incorporated information gathered from other naturalists—alongside Buffon he mentions the travel reports and Russian fauna by Peter Simon Pallas (1741–1811), but above all from contributions to journals that scientific "academies" (*Sozietäten*) edited in Paris, Stockholm, St. Petersburg and Vienna.[56] In the preface to a supplementary volume, which appeared in 1776, Müller even asked his readers to report any new discoveries, whether made from reading, in collections, or in the field, directly to him by providing at least a short description and

[54] Bettina Dietz, "Linnaeus' Restless System: Translation as Textual Engineering in Eighteenth-Century Botany," *Annals of Science* 73 (2016): 143–56.

[55] Martinus Houttuyn, "Voorreden", in *Natuurlyke Historie, of Uitvoerige Beschryving der Dieren, Planten, en Mineraalen, Volgens het Samenstel van den Heer Linnæus*, Del 1, Stuk 1, (Amsterdam, 1761), unpag.

[56] Philipp Ludwig Statius Müller, "Vorbericht," in *Des Ritters Carl von Linné vollständiges Natursystem nach der zwölften lateinischen Ausgabe, und nach Anleitung des holländischen Houttuynischen Werks*. *Erster Theil. Von den säugenden Thieren* (Nürnberg, 1773), unpag. For a more detailed account of Müller's sources, and his manner of compilation, see Dietz, "Linnaeus's restless system" (cit. n. 53), 148–149.

indication of the new species' taxonomic position.[57] When this supplementary volume came from the press, Müller unfortunately had died already, as the publisher Raspe explained in a note.[58] He expressed the wish to continue the project, however, and indeed, from 1777 to 1779 Johann Friedrich Gmelin (1748–1804), professor of medicine at the University of Göttingen, edited four volumes for Raspe covering the mineral kingdom, which were reprinted 1785; from 1777 to 1788 thirteen volumes covering botany were edited by two other naturalists; and from 1796 to 1808, the Raspe company printed a German translation of Gmelin's "thirteenth" edition of *Systema Naturae*.[59]

One can see from this short sketch that translations and editions of Linnaeus's *Systema Naturae* were products of intense paper work. They often built on one another, rather than directly on Linnaeus's own publications (see fig. 2), and they relied on a wide array of additional written sources—other general works in natural history, local floras and faunas, journal articles, and letters from correspondents—to integrate the latest discoveries. Thus Gmelin acknowledged his material debt to no less than 129 named naturalists in the preface of his landmark thirteenth edition of *Systema Naturae* (1788–1793), including those like Buffon or Michel Adanson (1757–1806) "who, by their strictures and invectives, have endeavored to depreciate the immortal labors of our illustrious

[57] Philipp Ludwig Statius Müller, "Vorbericht," in *Des Ritters Carl von Linné vollständiges Natursystem nach der zwölften lateinischen Ausgabe, und nach Anleitung des holländischen Houttuynischen Werks*. *Supplements- und Registerband* (Nürnberg, 1776), unpag.

[58] [Gabriel Nicolaus Raspe], "Nachricht des Verlegers," in *Des Ritters Carl von Linné vollständiges Natursystem* (cit. n. 56), unpag.

[59] Soulsby, *catalogue* (cit. n. 39), no. 96–100, 577. The volumes on botany are analyzed by Dietz, "Linnaeus's Restless System" (cit. n. 50), 150–152.

author [i.e. Linnaeus]."[60] Müller coined a revealing expression for the unflagging compilatory activity that lay behind such works. In advertising his supplementary volume, he emphasized that "all *Addenda, Apendices* and *Mantissae* of the Knight von Linné have been properly slotted in (*gehörig eingeschaltet*)," and that the same had happened to new species reported by other naturalists.[61]

[FIGURE 2]

Einschalten is a verb with overtones of mechanical or bureaucratic labor, and simply means to insert an object into a preexistent series of other objects without affecting the latter.[62] It thus expresses vividly how easy it had become to compile data on plant and animal species after the Linnaean reform. This is not to say that the adoption of Linnaean nomenclature was a smooth and immediate process. It was rather through a long, protracted, and regionally diverse process in which social and political relations were at stake, rather than a mere technological fix, that the full potential of

[60] Johann Friedrich Gmelin, "Ratio hujus novae editionis," in *Caroli a Linné. Systema Naturae per Regna Tria Naturae [...]. Editio Decima Tertia, Aucta, Reformata* (Leipzig, 1788), unpag. Translation taken from Gmelin, "Preface," in *The Animal Kingdom, or Zoological System, of the Celebrated Sir Charles Linnaeus. Class I. Mammalia: [...]. Being a Translation of That Part of the Systema Naturae as lately Published, with Great Improvements, by Professor Gmelin of Goettingen*, ed., transl. Robert Kerr (Edinburgh, 1792), 1–8, on p. 5. Notably, Kerr also insisted that he was not putting forward a "mere translation" but included "very large additions [...] from zoological writers of eminence" (ibid., ix).

[61] Müller, "Vorbericht" (cit. n. 56), unpag. I thank Sabina Leonelli for coming up with an ingenious translation for *einschalten*.

[62] Johann Christoph Adelung, *Grammatisch-kritisches Wörterbuch der hochdeutschen Mundart*, 4 vols. (1793–1802), Vol. 1, 1735. Adelung points out that the word was used primarily in the context of inserting "written sentences."

Linnaean nomenclature was realized.[63] A key element in this process was the fact that Linnaean names and taxa empowered naturalists who were situated in peripheral contexts or subaltern positions to build their own "paper empires" on the basis of purely derivative literary techniques like extraction, compilation, and re-arrangement of names and accompanying descriptions. Even Buffon, a life-long ardent opponent of the Linnaean reform, did not escape the maelstrom of information processing that was set free in this way. From 1801 to 1803, the poet René Castel, once deputy of Calvados for the *Assemblé legislative*, published a twenty-six-volume "new edition" of Buffon's *Historie naturelle* "classified by orders, genera and species according to Linnaeus' system and with [...] Linnaean nomenclature."[64]

4. Counting Species

Gmelin compared Linnaeus's work to an "admirably contrived edifice" constructed in such a manner "as to suffer [...] necessary additions, alterations, and improvements, without injuring its strength, permanency, or symmetry." Critics of Linnaean natural history, he argued, should consider "that such alterations, additions and improvements, as the *System of Nature* has hitherto required, have been made by the disciples of that great master"—disciples like himself, that is. This did not keep Lamarck from heavily criticizing Gmelin for having composed his work without "preliminary research", simply "by attaching to the genera and species already determined by Linnaeus all what

[63] Linnaean nomenclature shares this with other information technologies; see von Oertzen, this volume, on punch card technology; Nils Güttler, *Das Kosmoskop. Karten und ihre Benutzer in der Pflanzengeographie des 19. Jahrhunderts* (Göttingen, 2014), on biogeographic maps.

[64] René Richard Louis Castel, *Histoire naturelle de Buffon, classée par ordres, genres et espèces, d'après le systéme de Linné, avec les charactères génériques et la nomenclature Linnéenne*, 26 vols. (Paris, 1801–1803).

he found indicated as new in the works he consulted."[65] Similar attitudes shine through when Kant speaks of systems in natural history as mere "depositories" (*Registraturen*), or when Humboldt addressed contemporary naturalists as "sordid registrars" (*elende Registratoren*).[66] Such invectives became more and more common in the late eighteenth century, and reflect how the Linnaean way of doing natural history increasingly lost its former prestige, and was relegated to the nether world of mere manual labor. Other concerns than mere description and cataloguing, notably concerns with questions relating to the "natural affinities" among organisms and the "laws" governing their geographical and ecological distribution, therefore began to be foregrounded by naturalists who wanted to retain their authoritative status.[67]

But it is worth taking the invectives seriously for a moment. Already Müller had met similar criticisms, leveled against Houttuyn and himself, and answered them with the rhetorical question

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[65] Lamarck, Jean-Baptiste. "Sur les ouvrages généraux en histoire naturelle, et particulièrement sur l'édition du Systema Naturae de Linneus [sic], que M. J. F. Gmelin vient de publiér," *Actes de La Société d'Histoire Naturelle de Paris* 1, no. 1 (1792): 81–85, on p. 82. On the context of Lamarck's criticism—he was planning to publish his own "work analogous to the Sytema Naturae of Linnaeus" (ibid.)— see Giulio Barsanti, "Le 'Système de la Nature' de Lamarck (1794): Analyse d'un ambitieux projet avorté d'après un manuscrit oublié," in Blanckaert et al., *Le Muséum* (cit. n. 26), 219–28. Gmelin's thirteenth edition did indeed almost entirely build on published information; see T. J. Spilman, "Gmelin's 13th Edition of Systema Naturae: A Case of Neglect." *Entomological News* 78 (1967), 169–72.

[66] Quoted from Güttler, *Das Kosmoskop* (cit. n. 62), 57–58.

[67] Janet Browne, *The Secular Ark: Studies in the History of Biogeography* (New Haven, 1983); Philip F. Rehbock, *The Philosophical Naturalists: Themes in Early Nineteenth-Century British Biology* (Madison, Wisc., 1983); Stevens, *Development of Systematics* (cit. n. 31), ch. 9.

“But what is a whole system, if not a compilation?”[68] A striking feature of eighteenth-century taxonomic literature that reflects its compilatory nature well is the increasing role that numbers began to play in it (see fig. 3). Like in any proper register, species, genera and even taxonomic units occupying higher levels of the Linnaean hierarchy were numbered consecutively to create an additional layer of indices that could be used to establish chains of references across field notes, correspondence, collections, annotations and publications.[69] Numbering specimens in collections and gardens, or species entries in lists and catalogues, had a longstanding tradition in early modern natural history, to be sure.[70] But with Linnaean nomenclature and taxonomy, such numbers acquired a new level of meaning that is best explained by turning to a telling example of their day-to-day use in late eighteenth-century natural history.

[FIGURE 3]

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[68] Müller, “Vorbericht” 1773 (cit. n. 55), unpag.

[69] Dietz, “Contribution and Co-production” (cit. n. 51), 551–69; on Linnaeus’s own use of genera and species numbers, see Charlie Jarvis, “A Concise History of the Linnean Society’s Linnaean Herbarium, with some Notes on the Dating of the Specimens it Contains,” in *The Linnaean Collections*, Special Issue of *The Linnean*, ed. Brian Gardiner (London, 2007), 5–18; Charmantier and Müller-Wille, “Carl Linnaeus’s Botanical Paper Slips” (cit. n. 48), 224–225. Naturalists collecting for the Jardin des plantes in Paris were commanded to number herbarium specimens and seed-sacks; see Bourguet, “La collecte du monde” (cit. n. 26), 174. Humboldt was particularly obsessed with numbering specimens during his excursions in the Amazon region; see H. Walter Lack, “Botanische Feldarbeit: Humboldt und Bonpland im tropischen Amerika (1799–1804),” *Annalen des Naturhistorischen Museums zu Wien* 105 B (2004): 493–514.

[70] Staffan Müller-Wille, “Reproducing Species,” in *Secrets of Generation: Reproduction in the Long Eighteenth Century*, ed. Raymond Stephanson and Darren N. Wagner (Toronto, 2015), 37–58.

In 1768, the German naturalist Johann Reinhold Forster (1729–1798), then teaching at the Dissenter's College in Warrington, was asked by Thomas Pennant (1726–1798) to assist him in producing a volume on insects for his *British Zoology*. In 1770, Forster published a curious first product from his labors, entitled *A Catalogue of British Insects*. It consisted of a list of exactly 1004 Linnaean names of insect species, neatly lined up in two columns and numbered consecutively, both throughout, and within each genus. In addition, the list was structured by headings stating the genus name, again numbered consecutively (see fig. 4). The purpose of the catalogue, as well as the meaning of the abbreviations set against many of the species entries, were succinctly explained by Forster in the preface to his book:

> The author of this catalogue intends to publish a *Fauna* of *British Insects*; and as he thinks not to set out upon it, till he can offer to the public a work, as little imperfect as possible, and to give no other descriptions than from ocular inspection: he presents his most respectful compliments to all ladies and gentlemen who collect insects, and begs them to favour him, if possible, with specimens of such insects, as they can spare, and which he is not possessed of: for this purpose he has made this catalogue, and put no mark to the insects in his possession; those which he has so plentifully as to be enabled to give some of them to other collectors, are marked with a (*d*); those which he has not, are marked either *Berk*. signifying *Dr. Berkenhout's Outlines of the Natural History of Great Britain*; or *B.* signifying a manuscript catalogue of *British Insects* communicated to the author; or *B. B.* which signifies *Berkenhout*, together with the manuscript catalogue. *N. S.* is put to such insects as have not yet been described by Dr. *Linnaeus*, and are *new species* with new specific names.[71]

[71] John [sic] Reinhold Forster, *A Catalogue of British Insects* (Warrington, 1770), 2; emphases in the original. The "manuscript catalogue of *British Insects"* marked with a "B." probably referred to the insect collection of

At a glance, then, Forster's catalogue informed its readers of species he possessed in abundance, including species that were "new" to natural history as well as species he was hoping to acquire through exchange to complement his own collection. The "d" probably stood for "duplicate", a notion that notably does not seem to have existed in pre-Linnaean natural history.[72] There is evidence that Forster had used the same communication strategy in correspondence already, with one similar manuscript list preserved in the Linnaean collections at London.[73]

[FIGURE 4]

The strategy was apparently successful; an interleafed and annotated copy of Forster's *Catalogue* has been preserved, in which he carefully noted species he had received or come across, either by deleting the abbreviations *Berk.*, *B.* and *B. B.*, sometimes adding a "*d.*", or by noting additional species names on the interleaves, often followed by an "*N. S.*" and/or a "*d.*" (see fig. 3). A note on the flyleaf of this copy states "Aug. y[e] 28. 1771. 42 more insects", and a calculation at the very end of the catalogue registers "43 additional Insects" below the 1004 already listed, and draws up a new

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Anna Blackburne (1726–1798), an avid entomologist who corresponded with Forster and Linnaeus; see Arthur MacGregor, "Five unpublished manuscripts of Johann Reinhold Forster (1729–1798) in the archives of the Linnean Society of London," *Archives of Natural History* 42 (2015): 314–330, on 320.

[72] Giuseppe Olmi, "From the Marvellous to the Commonplace: Notes on Natural History Museums (16th -18th Centuries)," in *Non-Verbal Communication in Science prior to 1900*, ed. Renato G. Mazzolini (Florence, 1993), 235–78, on 252–61; Claudia Swan, "From Blowfish to Flower Still Life Paintings," in Smith and Findlen, *Merchants and Marvels* (cit. n. 23), 109–36, on 118; Delbourgo, "Collecting Hans Sloane" (cit. n. 26), 14.

[73] Arthur MacGregor, "Five unpublished manuscripts" (cit. n. 70).

sum total of 1047.[74] In the same year, 1771, Forster published a book presenting full species descriptions of one hundred "new" insect species. Again, an interleafed and annotated copy has survived from Forster's library, but now the annotations do not record accessions to his insect collection, but rather trace references to his descriptions of new species in entomological literature. Some of these annotations seem to be in the hand of Forster's son Georg (1754–1794), who would follow his father on James Cook's second circumnavigation in 1772.[75]

Forster's *Catalogue*, with its extreme reduction of content to species names arranged according to the Linnaean hierarchy, illustrates the degree to which classical natural history was partly dominated by concerns with naturalists' position within the "market" of natural history. Linnaeus concisely, if slightly disparagingly, defined collectors in his *Philosophia Botanica* as those "who were primarily concerned with the number of species."[76] How many species of a particular genus were out there "on offer", whether in the hands of other collectors, or out in the field? How many species had one already "acquired" in the form of specimens, and how many specimens could one "dispose of" as a kind of collector's capital to acquire specimens of other, preferably "new" or "rare" species? A whole new genre of taxonomic literature—consisting, like Forster's *Catalogue*, of nothing but taxonomic names, arranged in variously numbered and structured lists—emerged to answer these kinds of questions. Often openly advertising their poverty of content by incorporating expressions like "Index", "Nomenclator", or "Catalogue" in their title, these works, but especially their use, still await

[74] John [sic] Reinhold Forster, *A Catalogue of British Insects* (Warrington, 1770), Staatsbibliothek Berlin, Abteilung Historische Drucke, call no. Lt 12373R.

[75] Johann Reinhold Forster, *Novæ Species Insectorum: Centuria I* (London, 1771), Staatsbibliothek Berlin, Abteilung Historische Drucke, call no. Ls 3924.

[76] Linnaeus, *Philosophia Botanica* (cit. n. 42), 4: "Collectores de numero specierum Vegetabilium primario solliciti fuere."

analysis by historians of science.[77] The fact that some of them were actually auction catalogues produced to support the sale of a collection clearly indicates that the genre catered to the desires of collectors.[78] Anecdotal evidence shows, moreover, that such seemingly ephemeral works were also taken seriously as a source to systematically excerpt information on the existence and distribution of species.[79]

But there is more to Forster's *Catalogue*, and its countless cognates. His list of insect genera and species shows striking structural similarities with what is certainly one of the most intriguing visual representations in late eighteenth-century natural history, the "genealogical-geographical table of plant affinities" (*Tabula Genealogico-Geographica Affinitatum Plantarum*), that Paul Dietrich Giseke

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[77] For an intriguing study of the catalogues produced of the avian collections in the early history of the British museum, see Jennifer M. Thomas, "The documentation of the British Museum's natural history collections, 1760-1836," *Archives of Natural History*, 39 (2012), 111–125; in the 1830s and 1840s, John Edward Gray (1800–1875) closed a political debate around the British Museum's authority simply by publishing a catalogue of its natural history collections; see Gordon R. McOuat, "Cataloguing Power: Delineating 'Competent Naturalists' and the Meaning of Species in the British Museum," *British Journal for the History of Science* 34 (2001): 1–28.

[78] On auctions in natural history, see John Michel Chalmers-Hunt, ed., *Natural History Auctions 1700–1792: A Register of Sales in the British Isles* (London, 1976); Samuel J. M. M. Alberti, "Objects and the Museum," *Isis* 96 (2005), 559–71, on 564.

[79] The Staatsbibliothek Berlin holds an annotated copy of Gmelin's thirteenth edition of *Systema Naturae* (cit. n. 59; Staatsbibliothek Berlin, Abteilung Historische Drucke, call no. Le 2002-1). Most annotations list additional species, and end with the abbreviation "Hamb." or "Hamb. Catalog." This refers to *Catalogus Musei Zoologici Ditissimi Hamburgi* (Hamburg, 1796), an auction catalogue of the private collection compiled by Anton August Heinrich Lichtenstein (1753–1816). The annotations were probably made by his son Martin Hinrich Lichtenstein (1780–1857), who in 1810 became founding director of the Zoological Museum in Berlin.

(1741–1796) produced on the basis of his own and the entomologist Johann Christian Fabricius' (1745–1808) notes from private lectures they had been receiving from Linnaeus (see fig. 5). The table represents the plant kingdom in the form of 58 circles of different sizes and slightly irregular shape, distributed over the sheet in an unruly manner, a little bit like an archipelago. The accompanying "explication" of the table does indeed speak of a "map", and of the circles as "provinces" or "islands" (*insulae*), each of them standing for a particular "natural order" of plants, their "size (*amplitudo*)" corresponding to the number of genera in each order (*numeri Generum in quovis Ordine*), and their mutual relative positions expressing relations of "affinity" (*affinitas*).[80] The orders differ strikingly in "size," i.e. number of genera they contain (from 8 to 120), just as the numbers of species per genus differs conspicuously in Forster's *Catalogue*. Both documents thus create an impression of a landscape of abundance and scarcity, of remoteness and propinquity, knowledge of which the old Linnaeus apparently imparted on his disciples with the unmistakable air of a sage privy to the mysteries of nature.[81] The object of Linnaeus's speculations about a "natural" plant system may have been more lofty than that of Forster's *Catalogue*, but his manuscript

[80] *Caroli a Linne [...] Prælectiones in Ordines Naturales Plantarum*, ed. Paul Dietrich Giseke (Hamburg, 1792), 625. Giseke's *Tabula Genealogico-Geographica* became the model for many map- or network-like representations of the "natural system" that were published in the first half of the nineteenth-century; see Giulio Barsanti, *La Scala, la mappa, l'albero. Immagini e classificazioni della natura fra sei e ottocento* (Florence, 1992); Theodore W. Pietsch, *Trees of Life: A Visual History of Evolution* (Baltimore, 2013), 26–65. For a scrutiny of a particularly impressive "map" of bird affinities produced by Hugh Strickland in 1840, see Mary P. Winsor, "Considering affinity: an ethereal conversation," *Endeavour* 39 (2015), Iss. 1, 69–79, Iss. 2, 116–126, Iss 3-4, 179–187.

[81] See especially the dialogue on plant affinities and their recognition that Giseke reports to have had with Linnaeus in the summer of 1771 (*Praelectiones,* cit. n. 86, xv–xx). Linnaeus, Giseke claims, was constantly „chuckling (*subridens*)" at the naïvety of his student.

explorations of plant affinities took exactly the same form of numbered lists structured by headings, and were certainly of equal strategic importance in his dealings with other plant collectors.[82]

[FIGURE 5]

There is a further way in which Forster's *Catalogue* connects with the higher aspirations of late eighteenth- and early nineteenth-century naturalists. The catalogue he produced was one of *British* insects, and thus patently displayed a distribution of genera and species that was peculiar to the British Isles. Now, the shares that certain plant families held in the overall number of genera and species of a certain climate or region played a fundamental role in the attempts of Augustin de Candolle, Alexander von Humboldt, and Robert Brown to establish "laws" that governed the geographic distribution of plants in the second and third decades of the nineteenth century.[83] And again, the relationship of these endeavors to the practice of numbering species and genera in taxonomic works, especially local and regional floras and faunas, was not accidental.[84] All three naturalists had themselves been involved in large-scale floral projects – de Candolle assisted Lamarck in the third edition of his *Flore française* (5 vols., 1805), Browne prepared a survey of the Australian flora (*Prodromus Florae Novae Hollandiae*, 1810), and Humboldt and his travel companion

[82] Müller-Wille and Charmantier, "Lists as research technologies" (cit. n. 58), 750–52; see also Arthur J. Cain, "Linnaeus's *Ordines naturales*," *Archives of Natural History* 20 (1993), 405–415.

[83] On the early history of biogeography, see Gareth Nelson, "From Candolle to Croizat: Comments on the History of Biogeography," *Journal of the History of Biology* 11 (1978), 269–305; Browne, *The Secular Ark* (cit n. 74); James L. Larson, "Not without a Plan: Geography and Natural History in the Late Eighteenth Century," *Journal of the History of Biology* 19 (1986): 447–88; Güttler, *Kosmoskop* (cit. n. 62), ch. 1–3, esp. 181–185.

[84] On the genre of local and regional floras and faunas, see David E. Allen, „Four Centuries of Local Flora-Writing: Some Milestones," *Watsonia* 24 (2003): 271–280; Alix Cooper, *Inventing the Indigenous: Local Knowledge and Natural History in Early Modern Europe* (Cambridg, Engl., 2007), ch. 4 and 5.

Aimé Bonpland issued seven volumes on South-American plants (*Nova Genera et Species Plantarum*, 1815–1825) as part of their landmark travel account – and all three naturalists relied on floral catalogues for their calculations (fig. 6). A palpable example for the kind of labor that this involved can be found in a footnote that Humboldt added to his preface to the first volume of *Nova Genera et Species Plantarum* when presenting a table comparing the absolute and relative number of species per "natural family" for France, Germany and Lapland:

> Since our floras are for the most part arranged according to the artificial system of Linnaeus, [Karl Sigismund] Kunth, to whom I am much obliged for being in my service, transcribed the plants growing spontaneously under diverse [climatic] zones into natural orders; a labor which is truly cumbersome and protracted and if it had not been carried out in the most accurate manner, I could in no way have set out the arithmetic ratios of the geography of plants here. As far as the flora of France is concerned, I relied on communications by the famous Decandolle [sic].[85]

Karl Sigismund Kunth (1788–1850) also appears on the title page of *Nova Genera et Species*, but in a subaltern position, as the one who "put [the volume] into order from the handwritten paper slips (*schedis autographis*) of Aimé Bonland." Humboldt's remarks not only illustrate the longevity of Linnaeus's sexual system as a handy, diagnostic tool, but also show how its limitations could be

[85] Alexander von Humboldt, „De Instituto Operis et de Distributione Geographica Plantarum Secundum Coeli Temperiem et Altituinem Montium Prolegomena," in *Nova Genera et Species Plantarum Quas in Peregrinatione ad Plagam Aequinoctaliem Orbis Novi Collegerunt, Descripserunt, Partim Adumbracerunt Amat. Bonpland et Alex. de Humboldt*, Part 6 of *Voyage de Humboldt et Bonpland*, 7 vols. (Paris, 1815-1825), vol. 1 (1815), iii-lviii, n. 6 on xiii.

overcome by simple, if tedious, reallocation of species to their "natural families" or "orders."[86] One of the sources that Humboldt cites on the German flora, Heinrich Adolf Schrader's (1767–1836) *Flora Germanica*, provides a glimpse of how this task was sometimes made easier for Kunth. Alongside a 65-page long bibliography of the literature excerpted, Schrader included a list that numbered species and genera in exactly the same way, as explained above for Forster's catalogue.[87] Kunth could thus easily extract species numbers for each genus, and only needed to add these up for each of the natural families. Humboldt planned to publish a stand-alone, second edition of their biogeographic treatise once Kunth had returned from Paris to Berlin to become professor of botany and vice-director of the botanical garden, and throughout the rest of his life Kunth provided Humboldt with species numbers, partly drawn from what was to become his own *magnum opus*, a multi-volume "Enumeration of all plants hitherto known arranged according to their natural families."[88] The second edition never materialized, but the surviving letters and manuscripts show that Kunth's and Humboldt's speculations about relative and absolute species numbers involved the keen observation of how many species were known, above all, to naturalists at *other* important centers of botany, especially Paris.[89]

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[86] While I focus in this article on data-driven change in classical natural history, it is worth noting that Linnaeus' sexual system provides an excellent example for the kind of "data drag" that natural history was experiencing as well. The sexual system remained in use in natural history for almost a century although most naturalists, including Linnaeus, readily admitted that it was thoroughly "artificial". On data drag, see Kaplan, this volume.

[87] Heinrich Adolf Schrader, *Flora Germanica* (Göttingen, 1806), 83-100.

[88] Karl Sigismund Kunth, *Enumeratio Plantarum Omnium Hucusque Cognitarum Secundum Familias Naturales Disposita*, 5 vols. (Stuttgart: Cotta, 1833–1850).

[89] See the various letters and manuscripts by Kunth preserved in Alexander von Humboldt's papers (Staatsbibliothek Berlin, Nachl. Alexander von Humboldt, gr. Kasten 6, 8, and 13). On Kunth and Humboldt, see

[FIGURE 6]

Kunth clearly exemplifies one of the “sordid registrars” that a younger Humboldt had despised, but on whose activities he, like other naturalists with higher aspirations, had to rely on. “Registering” species with the help of Linnaean nomenclature and taxonomy was an activity that not only suggested that species should be counted, but in a far stricter sense, created the very condition for treating species and higher taxa as objects that could be counted meaningfully. As long as names and taxa had diagnostic functions, the number of “species” per “genus” was not much more than the analytical, and hence trivial, consequence of the diagnostic criteria adopted. However, once names and taxa were reduced to labels and containers in order to enhance the exchange of information—once the system they formed became a system of relations of equivalence, rather than difference—species numbers began to take on new, empirical meanings. That a genus “contained” so-and-so many species began to matter, whether for the amateur collector concerned with the completeness of his or her collection, the naturalist contemplating the unequal taxonomic or geographic distribution of species, or the politician wondering how “rich” in species national collections were. The Linnaean reform, that is, was not only a pragmatic affair, serving the needs of an emerging landscape of central institutions and increasing levels of division of labor in natural history. Its widespread adoption at the same time changed the ontological status of species from logical category to countable object.

William T. Stearn (ed.), *Humboldt, Bonpland, Kunth and Tropical American Botany* (Lehre, 1968). On „counting“ data in contexts of international competition, see Aronova this volume.

5. Conclusion: Data in Natural History and the History of Nature

It is well known that the irregular patterns that emerged from late eighteenth- and early nineteenth-century attempts to document the geographic and taxonomic distribution of species inspired de Candolle and Charles Lyell (1797–1875) to assume that species had been created independently of each other, at different times and places, and enjoying differential success in the "struggle for life", and that the same patterns also formed the chief *explanandum* of Darwin's theory of evolution by natural selection.[90] Paleontology, with its observations on the stratigraphic distribution of species, followed a similar trajectory; as David Sepkoski has argued, it grew into a "substantially 'data-driven'" discipline in the early nineteenth-century through the creation of tables and diagrams documenting changes in the "fossil record" of species over geologic time, and equally contributed in this form to the formation of evolutionary theories.[91] Are we then to assume after all, in the spirit of Lepenies, that it was an increasing "experiential pressure" from ever-heightened levels of accumulated and articulated data on the taxonomic, geographic and stratigraphic distribution of species that sparked the historization of nature?

In response to this question, it is worth pointing out two things. First, it remained of course perfectly possible to remain "ahistorical" in face of the strikingly irregular patterns of species distribution, and

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[90] François Jacob, *La Logique du vivant. Une Histoire de l'hérédité* (Paris, 1970), ch. 3; Janet Browne, "Darwin's Botanical Arithmetic and the 'Principle of Divergence,' 1854-1858," *Journal of the History of Biology* 13 (1980): 53–89; R. Alan Richardson, "Biogeography and the Genesis of Darwin's Ideas on Transmutation," *Journal of the History of Biology* 14 (1981): 1–41; Wolfgang Lefèvre, *Die Entstehung der biologischen Evolutionstheorie* (Frankfurt/M, 1984); Mary P. Winsor, „Darwin and Taxonomy," in *The Cambridge Encyclopedia of Darwin and Evolutionary Thought*, ed. Michael Ruse (Cambridge, 2013), 72–79.

[91] David Sepkoski, "Towards 'A Natural History of Data': Evolving Practices and Epistemologies of Data in Paleontology, 1800–2000," *Journal of the History of Biology* 46 (2013): 401–44.

to search for a hidden order behind them; most naturalists of the first half of the nineteenth century actually did so, and ideas of divine creation and directed evolution have survived the Darwinian revolution to this day. What does it mean to "historicize" nature anyway, if even Darwin and Wallace could not agree on some quite elementary points of their respective evolutionary theories"?[92] What meaning was assigned to the data that systematists, biogeographers and paleontologists accumulated clearly depended on other cultural factors than the mere form that these data took on once they were assembled to create new representations of the order of nature. On the other hand, it is equally clear that the ways in which data on the distribution of species was presented with the help of Linnaean nomenclature and taxonomy held an enormous potential for generating surprises. Giseke's map, or even Forster's little *Catalogue of British Insects*, was a clear affront to the old idea that nature formed a continuous and unchanging scale of perfection.[93]

The second point I would like to make concerns the nature of "data" in natural history. Humboldt continued to use this term, for example when describing Friedrich Sellow (1789–1831)—a naturalist collecting in Brazil for him and other big players in natural history like Joseph Banks—as having an "obsession with data". The journals left from Sellow's travels show that these "data" consisted in endless, numbered lists of the names of species collected, as well as where and when these were

[92] Jean Gayon, *Darwinism´s Struggle for Survival: Heredity and the Hypothesis of Natural Selection* (Cambridge, 1998) , ch. 1; Melinda B. Fagan, "Wallace, Darwin, and the Practice of Natural History," *Journal of the History of Biology* 40 (2007): 601–35; Wolfgang Lefèvre, *Das "Ende der Naturgeschichte" neu verhandelt. Historisch-genealogische oder epigenetische Neukonzeption der Natur?*, vol. 476, Max Planck Institute for History of Science Preprint (Berlin, 2016).

[93] According to Harriet Ritvo, *The Platypus and the Mermaid and Other Figments of the Classifying Imagination* (Cambridge, Mass., 1998), this is exactly what accounts for the immense popularity of natural history in the period dealt with here.

collected.[94] Just as with Forster's *Catalogue*, almost nothing can be gleaned from these entries about the properties of the plants and animals encountered, their local environments, or their local uses. So, the "data" that was recorded in this way was not data that provided information *about* organisms, but rather what we would call "metadata" today, i.e. data that helped to identify sources of information, and which, in classical natural history, consisted of a proper name, allocation to taxonomic rank, and information on date and place of provenance.[95] Humboldt's early call for "more data" to unravel the "laws" that governed the distribution of plant species essentially did not ask for much more than this. The infrastructure of "labels" and "containers" created by the Linnaean reform, that is, began to acquire a life of its own as a research subject, producing phenomena that could not have been produced without it. This is true in particular for the taxonomic distribution of species, since stating the number of species per genus, or the number of genera per natural family, remains totally within the ontology that this infrastructure created in the first place.

Classical natural history, and its post-Darwinian heir, the discipline of systematics, thus can indeed, first and foremost, be considered as an *information science*, that is, as a science whose primary aim consists in the storage, organization, and mobilization of knowledge.[96] But if this is true, it can also be considered as inherently "experimental" in its own specific ways, in the sense of building on art and artifice to produce new knowledge. Through the accumulation of specimens, containers, labels and other inscriptions naturalists bring together objects – on the page of a handwritten or printed

[94] Hanns Zischler, Sabine Hackethal and Carsten Eckert (eds), *Die Erkundung Brasiliens: Friedrich Sellows unvollendete Reise* (Berlin: 2013).

[95] See Krajewski, this volume, on the concept of metadata in library science. There are a striking parallels with Friedrich's account of early modern genealogical practices as well.

[96] Ernst Mayr, "Systems of ordering data," *Biology and Philosophy* 10 (1995): 419-434; Quentin D. Wheeler, ed., *The New Taxonomy*, Vol. 76 of *The Systematics Association Special Volume Series* (Boca Raton, 2008).

text, in a drawing or diagram, within the drawer or cabinet of a museum depot, or in the showcase of an exhibition gallery – that normally would *never* have co-existed. It is this peculiarity that endowed classical natural history, despite the occasionally dull appearance of its products, with its very own condition of creativity. The epochal shift from natural history to the history of nature, was thus not produced with a kind of teleological necessity through the accumulation of data; but the instruments and infrastructures brought into play to manage and enhance flows of data—Linnaean names and taxa, above all—generated unforeseen, and indeed, never-before-seen phenomena that were difficult to reconcile with long-held intuitions.

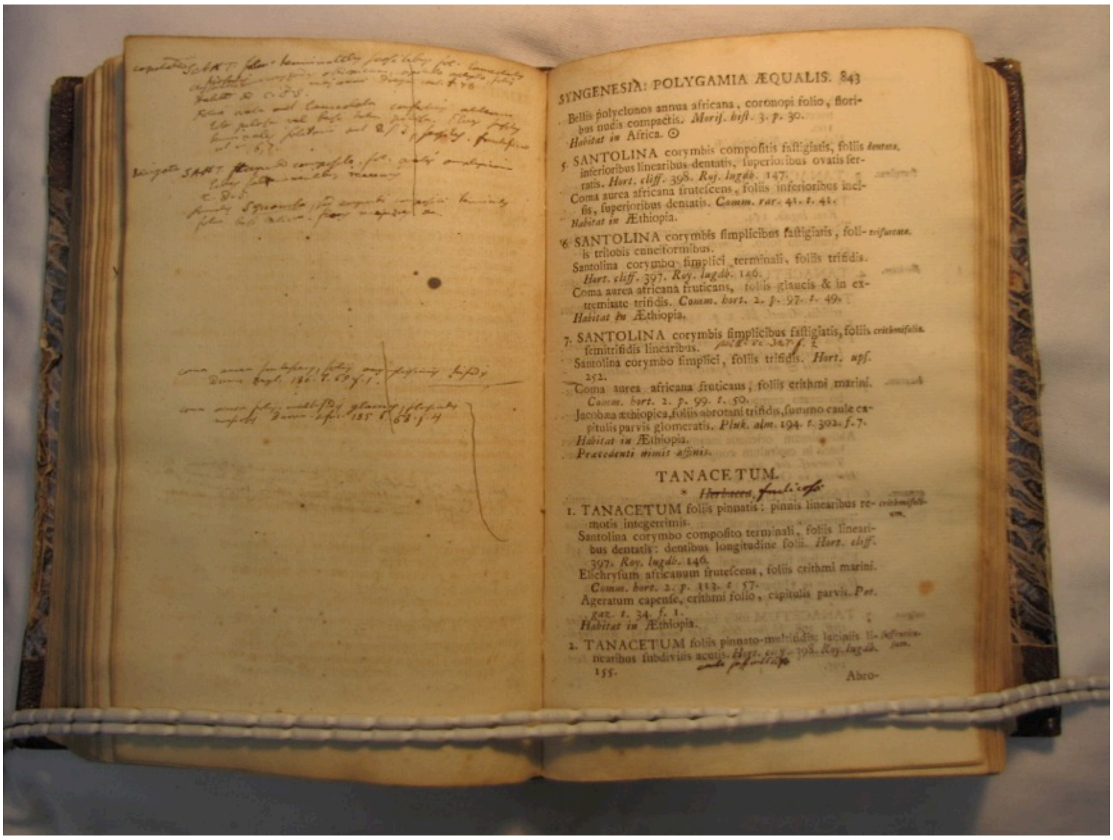
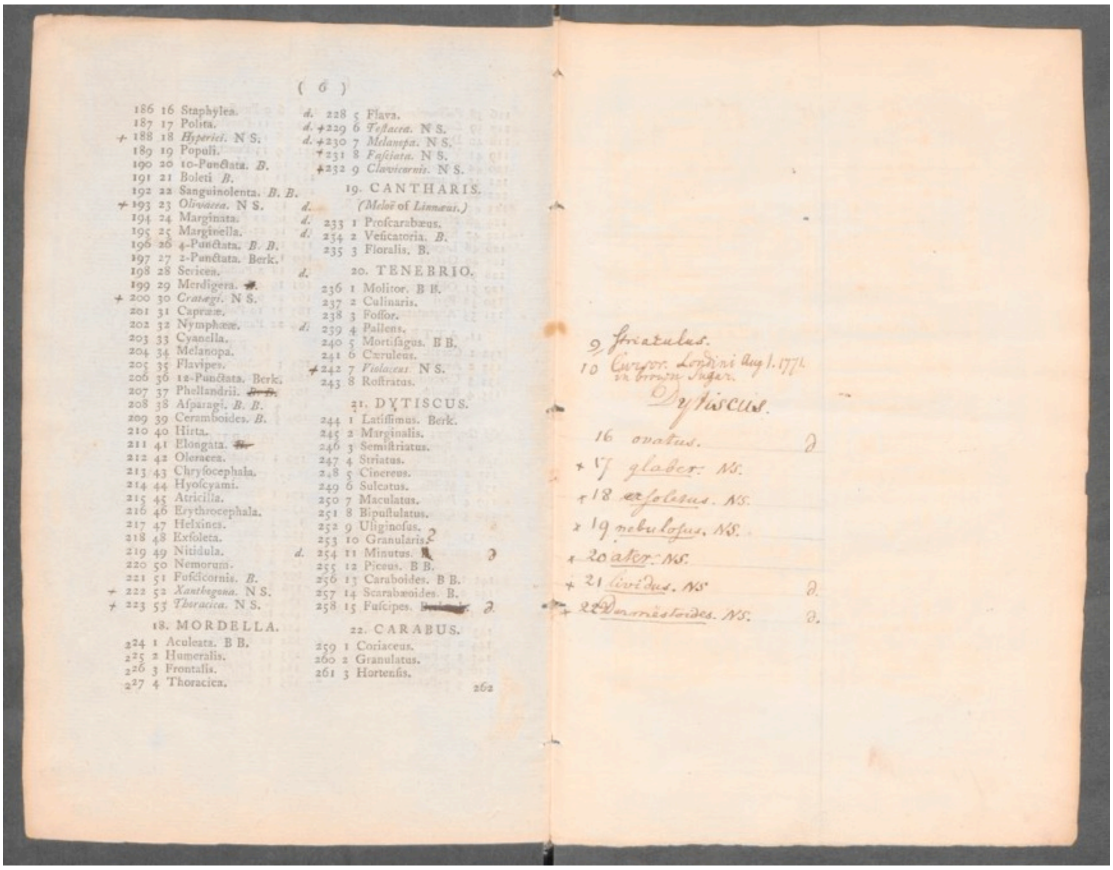


Fig. 1: *Page from Carl Linnaeus' own, interleafed and annotated copy of his* Species Plantarum *(Stockholm: Salvius, 1753). Note that each entry for a species in the printed text follows a strict layout and order, and occupies roughly the same space. Each entry starts with a serial number and the genus name (in small capitals), followed by a short diagnostic phrase distinguishing the species from other species of the same genus as well as references to works (in italics) that mention the species under that name. The genus name and the diagnostic phrase together form what Linnaeus called the "legitimate" name of species. The subsequent paragraphs list "synonyms", that is, alternative legitimate names under which the species was treated in the literature, again with references in italics. Most entries then end with a few short notes, partly employing symbols, containing additional information on geographic distribution, ecological habitat, life-cycle, and taxonomic position. On the margin, against the first line of each entry, the specific epithet is noted which, together with the genus name, forms the "trivial" name of each species. In addition, the text is structured by headings naming the genus, and sometimes further subdivisions within the genus. The header spells out the class and order in Linnaeus's sexual system to which the genus belongs. Linnaeus' annotations were made in preparation of a new edition of* Species Plantarum *and include corrections and short additions that are entered directly in the printed text, and entries for new species and synonyms on the facing page. Note that the latter*

almost exactly emulate the typographic layout of the printed text, and that the position where they are to be inserted is either directly indicated by their position on the page or with the help of a drawn line. Interestingly, in this case Linnaeus seems to have decided that two species referred to in the literature under the genus name Coma *are to be redistributed onto the genera* Santolina *and* Tanacetum*. Linnean Society, London, Library and Archives, Linnaean Collections, call no. BL83. Courtesy Linnean Society of London (www.linnean.org).*

Fig. 2: *Frontispiece and title page of* Des Ritters Carl von Linné Lehr-Buch über das Natur-System *(Nürnberg, 1781). This was a shortened version of Philip Ludwig Statius Müller's seven-volume* Des Ritters Carl von Linné vollständiges Natursystem *(Nürnberg, 1773–1776), which was prepared by the clergyman Jeremias Höslin (1722–1789) "for everybody, rather than scholars," as he stated in the preface. The inscriptions on the large volume and plaque held by a putto illustrate the succession of publications that the book builds on: "Linnaeus composuit" points to the Swedish naturalist's tenth edition of* Systema Naturae*, "Houttuÿnius explicavit" to Houttuyn's expanded "translation" of that edition (started in 1761), and "Mullerus ad Ed. XII reformavit" to Müller's attempt to provide a synthesis of Houttuyn's edition and Linnaeus own twelfth edition of* Systema Naturae *(1766–68) as well as later works. Courtesy Staatsbibliothek zu Berlin – Preußischer Kulturbesitz.*

***Fig. 3:** Frontispiece of the first volume of* Caroli Linnaei [...] Systema Naturae*, edited by Johann Joachim Lang (Halle and Magdeburg, 1760). This edition was a pirated reprint of Linnaeus' tenth edition, and may be the one Linnaeus referred to as the eleventh edition in his own. The frontispiece shows a statue of Diana, and is a variation of the frontispiece of Linnaeus's* Fauna suecica *(Leiden: Wishoff, 1746), adding a human figure taking notes and pointing at the monkey in the top of the tree to the right. The heading refers to "names and numbers" (*numeros et nomina*) as essential elements of Linnaean natural history. The accusative is odd, but may just express that "names and numbers" are what naturalists should work towards.*



(6)

186 16 Staphylea.
187 17 Polita.
+ 188 18 *Hyperici.* N S.
189 19 Populi.
190 20 10-Punctata. *B.*
191 21 Boleti *B.*
192 22 Sanguinolenta. *B. B.*
+ 193 23 *Olivacea.* N S.
194 24 Marginata.
195 25 Marginella.
196 26 4-Punctata. *B. B.*
197 27 2-Punctata. Berk.
198 28 Sericea.
199 29 Merdigera.
+ 200 30 *Cratægi.* N S.
201 31 Capreæ.
202 32 Nymphææ.
203 33 Cyanella.
204 34 Melanopa.
205 35 Flavipes.
206 36 12-Punctata. Berk.
207 37 Phellandrii.
208 38 Asparagi. *B. B.*
209 39 Ceramboides. *B.*
210 40 Hirta.
211 41 Elongata.
212 42 Oleracea.
213 43 Chrysocephala.
214 44 Hyoscyami.
215 45 Atricilla.
216 46 Erythrocephala.
217 47 Helxines.
218 48 Exfoleta.
219 49 Nitidula.
220 50 Nemorum.
221 51 Fuscicornis. *B.*
+ 222 52 *Xanthogona.* N S.
+ 223 53 *Thoracica.* N S.

18. MORDELLA.

224 1 Aculeata. B B.
225 2 Humeralis.
226 3 Frontalis.
227 4 Thoracica.

d. 228 5 Flava.
d. +229 6 *Testacea.* N S.
d. +230 7 *Melanopa.* N S.
+231 8 *Fasciata.* N S.
+232 9 *Clavicornis.* N S.

19. CANTHARIS.
d. (*Meloë* of *Linnæus.*)

d. 233 1 Proscarabæus.
d. 234 2 Vesicatoria. *B.*
235 3 Floralis. B.

d. 20. TENEBRIO.

236 1 Molitor. B B.
237 2 Culinaris.
238 3 Fossor.
d. 239 4 Pallens.
240 5 Mortisagus. B B.
241 6 Cæruleus.
+242 7 *Violaceus.* N S.
243 8 Rostratus.

21. DYTISCUS.

244 1 Latissimus. Berk.
245 2 Marginalis.
246 3 Semistriatus.
247 4 Striatus.
248 5 Cinereus.
249 6 Sulcatus.
250 7 Maculatus.
251 8 Bipustulatus.
252 9 Uliginosus.
253 10 Granularis.
d. 254 11 Minutus.
255 12 Piceus. B B.
256 13 Caraboides. B B.
257 14 Scarabæoides. B.
258 15 Fuscipes.

22. CARABUS.

259 1 Coriaceus.
260 2 Granulatus.
261 3 Hortensis.

262

9 striatulus.
10 Cursor. Londini Aug 1. 1771 in brown sugar.
Dytiscus.
16 ovatus.
+ 17 glaber: NS.
+ 18 exfoletus. NS.
+ 19 nebulosus. NS.
+ 20 ater: NS.
+ 21 lividus. NS
+ 22 Dermestoides. NS.

Fig. 4: *Two pages from Johann Reinhold Forster,* A Catalogue of British Insects *(Warrington, 1770) with annotations by its author. The printed text lists genera and species of insects, employing Linnaean trivial names. The notes document additional species that Forster came across after publication, many of them marked as new species ("NS."), and in one case reporting when and where a species was found: "10. [Tenebrio] Cursor. Londini Aug 1. 1771. in brown sugar." The latter remark is probably referring to a beetle from Florida, known as the "sawtoothed grain beetle," that established itself in Europe as a pest on stored foods. Forster, or his informant, may have come across this species in a shipment of sugar. Courtesy Staatsbibliothek zu Berlin – Preußischer Kulturbesitz.*

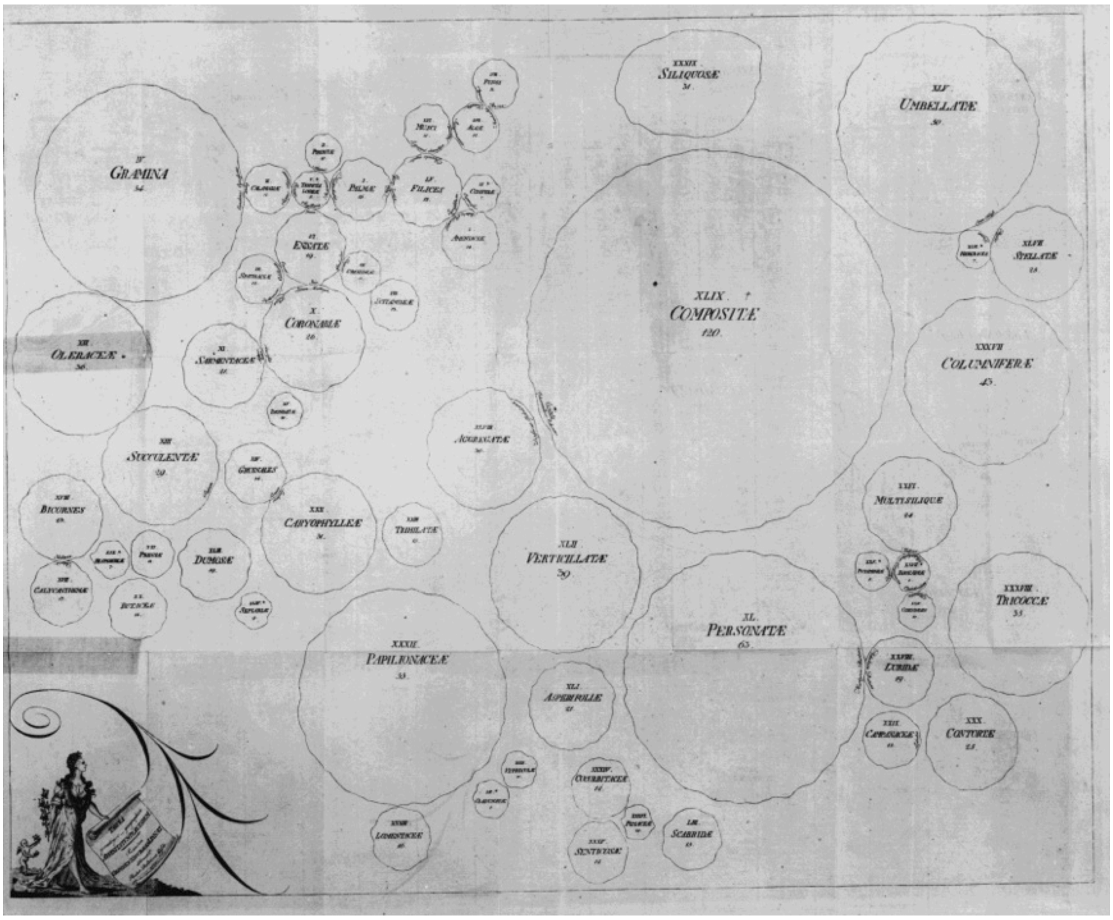


Fig. 5: *"*Tabula Genealogico-Geographica Affinitatum Plantarum*" from* Caroli Linnaei Praelectiones in ordines naturales plantarum*, edited by Paul Dietrich Giseke (Hamburg, 1790). The circles represent "natural orders" or plant families, their size the number of genera they contain. This number is also noted in the center of each of the circles, alongside the family's name and a Roman numeral. The relative position of each circle indicates its taxonomic relationship with other families, sometimes highlighted by inscribing the names of closely related genera on the inside of circles where these approach each other.*

FAMILIÆ NATURALES.	NUMERUS SPECIERUM in			RATIO CUJUSQUE FAMILIÆ ad universam copiam Phanerogamarum in		
	Gallia.	Germania.	Laponia.	Gallia.	Germania.	Laponia.
Cyperoideæ.	134.	102.	55.	1/27	1/18	1/9
Gramineæ.	284.	143.	49.	1/13	1/13	1/10
Junceæ.	42.	20.	20.	1/86	1/94	1/25
Tres fam. præcedentes. .	460.	265.	124.	1/8	1/7	1/4
Orchideæ.	54.	44.	11.	1/67	1/43	1/45
Labiatæ.	149.	72.	7.	1/24	1/26	1/71
Rhinantheæ et Scrophul.	147.	76.	17.	1/24	1/24	1/29
Boragineæ.	49.	26.	6.	1/74	1/72	1/83
Ericeæ et Rhodod. . .	29.	21.	20.	1/125	1/90	1/25
Compositæ	490.	233.	38.	1/7	1/8	1/13
Umbelliferæ.	170.	86.	9.	1/34	1/22	1/55
Cruciferæ	190.	106.	22.	1/19	1/18	1/23
Malvaceæ.	25.	8.	o.	1/145	1/235	o.
Caryophylleæ	165.	71.	29.	1/22	1/27	1/17
Leguminosæ	230.	96.	14.	1/16	1/18	1/35
Euphorbiæ.	51.	18.	1.	1/71	1/104	1/497
Amentaceæ	69.	48.	23.	1/52	1/39	1/21
Coniferæ.	19.	7.	3.	1/192	1/269	1/165
Phanerogamæ.	3645.	1884.	497.	o.	o.	o.

Gallia, lat. 42 ½° — 51° Calor med. annuus 16°,7—11°. (Calor medius æstatis 24°—19°. Menses quorum calor med. 11° superat: Mart. — Nov. et Mai. — Sept.)
Germania, lat. 46°—54°. Cal. med. 12°⅓—8°½ (Cal. æstiv. medius 21°—18°. Menses quorum cal. med. 11° superat: Apr. — Oct. et Mai. — Sept.)
Laponia, lat. 64°—71°. Cal. med. + 1° ad — 8°,8. (Cal. med. æst. 13°—7°. Mens. ultra 11°: Jun. — Aug. et Jun. — Jul.)

Fig. 6: *Table comparing the species composition of three floral regions, France (*Gallia*), Germany (*Germania*), and Lapland (*Laponia*). The column to the left lists plant families, while the two columns to the right record the absolute and relative number of species in the respective family for each of the three floral regions. Below the table, some basic information on each region's climate is provided (latitude, mean temperatures for the whole year and the summer, as well as number of moths where the temperature rises above 11°C*)*. Source: Alexander von Humboldt, "De Instituto Operis et de Distributione Geographica Plantarum Secundum Coeli Temperiem et Altitudinem Montium Prolegomena," in* Nova Genera et Species Plantarum quas in Peregrinatione ad Plagam Aequinoctaliem Orbis Novi Collegerunt, Descripserunt, partim Adumbracerunt Amat. Bonpland et Alex. de Humboldt, *Part 6 of* Voyage de Humboldt et Bonpland, *7 vols. (Paris, 1815-1825), 1(1815): xiv.*